TO: **Implementation Team**
FROM: **PATH Planning Group**
SUBJECT: **Corrections to PATH Preliminary Report**
DATE: **August 4, 1998**

PATH is currently engaged in the Weight of Evidence process for spring/summer chinook, as described in the May 28 memo to the I.T. One of the tasks in this process is to conduct a sensitivity analysis of the PATH modeling results. As we looked in more detail at the results in the March 1998 Preliminary Decision Analysis Report, we have discovered some errors in some of the inputs on which the preliminary set of results are based, and have made other revisions to the assumptions that were used in the preliminary analyses. These revisions and corrections of errors in the preliminary analyses have changed the projected outcomes of the three actions A1, (current management), A2 (full transportation) and A3 (natural river drawdown of 4 Snake River dams) from the results presented in the Preliminary Report. The revised set of results is currently being reviewed by PATH scientists, together with the first draft of the Weight of Evidence report (completed by ESSA on July 3rd).

The purpose of this memo is to notify the I.T. of these changes in PATH modeling results since the Preliminary Decision Analysis Report for Spring/Summer chinook was completed in March 1998. We have done this by correcting the Executive Summary of the Preliminary Report, which is attached. The thirteen results and conclusions in the original Executive Summary fall into three groups:

- Significant changes in results and conclusions, indicated by highlighting (i.e. Figures E-1 and E-2, and paragraphs 2, 3, 4, 6, 9, and 10).
- Minor changes in results, but basic conclusions unchanged (i.e. paragraphs 1, 7, 8 and 11).
- Results and conclusions that we have not yet redone (i.e. paragraphs 5, 12, and 13).

Note that since the revised set of results was completed, a number of new hypotheses and additional revisions to the models have been proposed and are currently being reviewed by PATH. These new hypotheses and proposed changes to the current models are not reflected in the revised set of results. Further changes in results are likely when these new hypotheses and proposed changes to the models have been incorporated into the models. In addition, it is important to note that as in the previous preliminary report on results, all hypotheses that are currently included in the models are given approximately equal weight. Therefore additional changes are also likely as the weight of evidence process proceeds and different weights are applied to hypotheses. For the final analyses, additional hydro management alternatives (such as transportation with improved collection and John Day Drawdown) will further broaden the range of results. The inclusion of habitat, hatchery, and harvest alternatives and sensitivity analyses in future analyses will also provide additional information regarding the ability of hydro actions to meet the jeopardy standards.

Changes in Modeling Assumptions and Inputs since the March 1998 Preliminary Decision Analysis Report

1. Historical estimates of "D" values (ratio of post-Bonneville survival of transported fish: non-transported fish) generated by the CRiSP/TRANS4 passage/transportation model have been corrected to model the T/C release groups instead of the run at large to determine the historic survival of control fish, and historic D values. The revised set of D values implements

estimates described in the Document "Recent Analyses of D Values" (Anderson, January 1998), which was distributed with the Preliminary Decision Analysis Report in March 1998. The effect of this change is to increase the probabilities of achieving jeopardy standards with the CRiSP/TRANS4 model for actions A1 and A2.

2. CRiSP in-river survival rates of non-transported fish from the head of Lower Granite pool to below Bonneville Dam (Vn) under A3 have changed to more accurately model hypothesized changes in juvenile survival under drawdown. New CRiSP A3 Vn's are higher than those used in preliminary report, and are similar to A3 Vn's projected by the FLUSH passage model. The effect of this change is to increase the probabilities of achieving jeopardy standards with the CRiSP model for action A3.

3. PATH projections of spawner abundances use two versions of a life-cycle model. One of these versions, the "Alpha model", uses empirical estimates of flows measured at Astoria as an input. The preliminary analyses used an incorrect set of Astoria flows. The revised set of results uses the correct data. These changes have minimal effects on overall results.

4. The preliminary analyses considered two hypotheses about the response of stock productivity to freshwater habitat effects. One of these was a status quo scenario, in which stock productivity was assumed not to change. The other habitat hypothesis considered the effects of additional protection / enhancement. We have since discovered the additional protection / enhancement habitat scenario was implemented incorrectly. The revised set of results therefore includes only the status quo habitat option (i.e. no change in productivity).
5. The Preliminary Report included more FLUSH than CRiSP passage model runs because not all of the scenarios run by FLUSH were run by CRiSP. Since the Preliminary Report was produced, we have received the remainder of the CRiSP runs, which are included in the revised set of results. There are three extra mortality hypotheses and two future climate hypotheses, but only 5 of the 6 possible combinations of these hypotheses make sense. Therefore the hydrosystem and BKD extra mortality hypotheses are each represented in 40% of the runs, while the regime shift extra mortality hypothesis is represented in 20% of the runs.

As we mentioned previously in our May 28th memo to the I.T., techniques such as decision analysis help to clarify risks to stocks by quantifying the effects of uncertainties. Decision analysis will not provide a single answer about stock responses to specific actions; rather, it will show which actions are most robust to the uncertainties. That is, it will show which actions are safest or most risk-averse, given the range of hypotheses and uncertainties in future climate.

Executive Summary

Introduction

The Plan for Analyzing and Testing Hypotheses (PATH) is a formal and rigorous program of formulating and testing hypotheses. It is intended to identify, address and (to the maximum extent possible) resolve uncertainties in the fundamental biological issues surrounding recovery of endangered spring/summer chinook, fall chinook, and steelhead stocks in the Columbia River Basin. This process grew out of previous efforts by various power regulatory and fisheries agencies to compare and improve the models used to evaluate management options intended to enhance recovery of these stocks.

The objectives of PATH are to:

1. determine the overall level of support for key alternative hypotheses from existing information, and propose other hypotheses and/or model improvements that are more consistent with these data;
2. assess the ability to distinguish among competing hypotheses from future information, and advise institutions on research, monitoring and adaptive management experiments that would maximize learning; and
3. advise regulatory agencies on management actions to restore endangered salmon stocks to self-sustaining levels of abundance.

This report describes the methods and results of the decision analysis framework we have used to address the third objective for Snake River spring/summer chinook salmon. The specific purposes of this preliminary decision analysis report are to: 1) test the methods of decision analysis we have formulated over the last two years; 2) provide decision makers with our **preliminary** insights into the range of potential responses of Snake River spring/summer chinook to alternative management decisions; and 3) characterize the magnitude of various uncertainties and demonstrate their relative importance in affecting the outcomes of alternative management decisions.

The preliminary decision analysis builds on the “retrospective” analyses completed to date by PATH under our first objective. PATH retrospective analyses attempt to identify the major spatial and temporal patterns in abundance, productivity, and survival of these stocks over the last 30 to 40 years and to determine the relative contribution of Habitat, Harvest, Hatchery, Hydro, and Climatic influences to these patterns. Results of these analyses were published in the peer-reviewed PATH FY96 Retrospective Analysis report, and summarized in “Conclusions of FY96 Retrospective Analyses”, a consensus document written by PATH scientists in December, 1996. Other retrospective analyses were completed in FY97, and have now been published (Retrospective and Prospective Analyses of Spring/Summer Chinook Reviewed in FY1997; published April 1998). All of the retrospective analyses completed to date are considered in this report.

PATH retrospective analyses have helped to bring a substantial set of empirical information to bear on alternative hypotheses to explain recent declines and have led to considerable improvements in both our understanding and modeling approaches. In addition, there has been considerable convergence on the historical data sets to use in calibrating and testing models, and on many of the assumptions to be made when projecting future population changes.

The PATH retrospective analyses have also highlighted some major uncertainties in past and current conditions that have yet to be resolved because of incomplete data and differences in interpretation. These uncertainties, along with uncertainties in projecting future conditions, imply that a single management action can have a number of possible outcomes, depending on what is assumed about past, present, and future conditions. This range of possible future outcomes of management actions is best captured by modeling salmon populations under a set of alternative hypotheses about uncertain components of the system.

The preliminary decision analysis described in this report looks systematically at the outcomes of management actions under several alternative hypotheses about biological mechanisms that link actions to possible outcomes. This approach was recommended by the SRP and by independent scientists within PATH as a tool for explicitly considering uncertainties in the decision-making process, in recognition that decisions cannot wait for all uncertainties to be resolved. A variety of management objectives can be used to evaluate alternative actions.

Review of this preliminary analysis is leading to refinements in methods and consideration of additional alternative hypotheses. These improvements will be incorporated in the final decision analysis report for spring/summer chinook. The final report will also present analyses of additional management actions to those evaluated in this report (including drawdown of John Day Dam and transportation with increased collection), and will endeavor to reach consensus to the maximum extent possible on the relative weights assigned to alternative hypotheses based on the strength of supporting evidence and our professional judgements. We anticipate, however, that lack of evidence will constrain our ability to reach consensus on the relative likelihood of some alternative hypotheses.

For the next four months, PATH intends to focus on completing analyses for fall chinook before returning to spring/summer chinook. We are distributing this preliminary report now rather than wait until the above refinements are made to show what we have been doing and where we are headed. The final report for spring/summer chinook (which will incorporate the above revisions) will be completed by the fall of 1998.

Decision Options

Although many agencies have drafted some very broad goals to help direct decision making, this decision analysis is focused on a narrower question: **To what extent can**

alternative hydrosystem actions prevent extinction and lead to recovery of stocks either listed or proposed for listing, including wild spring/summer chinook, fall chinook and steelhead stocks in the Snake River and mid-Columbia region? This preliminary decision analysis considers three alternative hydrosystem actions: A1 (current operations), A2 (maximize transportation without surface collectors), and A3 (drawdown to natural river level of the four Lower Snake dams). We chose this restricted set of options to allow a thorough evaluation of our biological decision analysis and modeling tools by both PATH scientists and decision-makers. We believe that the next options to be evaluated should be B1 (natural river drawdown of both the four Lower Snake dams and John Day Dam), maximizing transportation with surface bypass collectors (A2'), and the in-river option (A6), so as to bracket the potential range of responses of fish populations.

While PATH is only looking at hydrosystem decisions explicitly, the effects of habitat and harvest management actions are being considered in sensitivity analyses. We are also developing approaches to including uncertainties with respect to management of hatcheries, to be added to our final report. The approaches used for all four H's (hydro, habitat, harvest, hatcheries) will be re-examined following peer review of this report.

We also intend to explore options for an experimental management approach, which varies management actions over time and space in a deliberate attempt to test key hypotheses. An experimental management approach has been recommended by some members of the PATH Scientific Review Panel because some of the major uncertainties are difficult to resolve with current information. Though experimentation may pose risks to these stocks, there is risk inherent in any actions, including continuing present operations, as these populations are at dangerously low levels.

How to Assess the Outcomes of the Options

Outcomes of the alternative actions will depend on what is assumed about past, present and future conditions experienced by fish in response to management actions. The previous PATH retrospective analyses have elucidated a great deal, and have also pointed out uncertainties in past conditions due to incomplete data and potentially confounding influences. These uncertainties generate a range of alternative assumptions about historical conditions, which are used in retrospective modeling analyses that generate quantitative estimates of parameters needed to run models into the future. Results from the retrospective analysis are passed to the prospective modeling analysis, which quantifies the range of possible futures. This set of possible futures depends not only on the understanding and parameter estimates gleaned from the retrospective analysis, but also on assumptions about future conditions (such as climate) and the response of stocks to new management actions (such as Snake River drawdown).

The outcomes of alternative hydro management actions are evaluated in terms of various performance measures. These measures are used to rank alternative actions according to how well they meet specified management goals. A variety of performance measures have been developed to assess the biological implications of different management actions. Because our primary goals are to determine the hydrosystem actions that should be taken to prevent extinction and lead to recovery of endangered stocks, we focus here on the National Marine Fisheries Service (NMFS) jeopardy standards that account for each of these goals. These standards are a measure of the ability of actions to increase the spawning abundance of stocks to levels associated with long-term persistence and stability. Survival standards are based on projected probabilities that the spawning abundance will exceed a pre-defined "survival" threshold over a 24 or 100 year simulation period; survival standards are met when that probability is 0.7 or greater. Recovery standards are based on probabilities of exceeding a "recovery" threshold in the last eight years of a 48-year simulation period; this standard is met when the probability is 0.5 or greater.

The standards are applied to the sixth best stock out of the seven Snake River "index" stocks of spring/summer chinook (Imnaha, Minam, Bear Valley/Elk, Sulphur Creek, Marsh Creek, Johnson Creek, and Poverty Flats) to ensure that most of the stocks are able to meet the survival and recovery goals. These seven index stocks are the only ones for which sufficient historical data exist to develop spawner-recruit relationships, required for generating projections of future stock sizes. Further work is required to generalize results from these stocks to all wild chinook populations of the Snake River basin.

Uncertainties in the Response of Populations to Management Actions

There are many uncertainties that can potentially affect the responses of fish populations to management actions. We have focused on twelve of the most important of these uncertainties, and have laid out a range of alternative hypotheses for each. The uncertainties are of two types: uncertainty regarding the future environment, and uncertainty regarding how the system works (i.e., the survival changes caused by management actions). Although the future environment may be beyond human control (e.g., future climate), the uncertainty inherent in projecting it is of potential significance in determining future population sizes. Alternative hypotheses to describe how the system works often hinge on the interpretation of historical information, because the functional relationships in models are based on both general principles and historical data. However, as past information is incomplete, there are differing interpretations of the relative importance of different factors in causing recent declines of Snake River spring-summer chinook.

The twelve uncertainties considered in the preliminary decision analysis were:

1. *Passage assumptions* – uncertainty in direct survival of in-river fish, and the partitioning of in-river survival between dam and reservoir survival.
2. *Fish guidance efficiency (FGE)* – uncertainty in the effectiveness of extended-length screens in diverting fish away from the turbines, relative to standard-length screens.
3. *Turbine/Bypass Mortality* – uncertainty in historical estimates of bypass and turbine mortality for some projects prior to 1980.
4. *Predator Removal Effectiveness* – uncertainty in the effect of the predator removal program (i.e., removal of squawfish for bounties) on survival of salmon smolts in reservoirs.
5. *Transportation assumptions* – uncertainty in the relative survival of transported and non-transported fish after the fish have exited the migration corridor (i.e., below Bonneville Dam).
6. *Stock productivity* – uncertainty in the extent to which Snake River and lower Columbia stocks share common mortality effects.
7. *Extra mortality* – uncertainty in the mortality of both transported and non-transported fish occuring beyond Bonneville Dam.
8. *Future climate* – uncertainty in future patterns in climatic conditions.
9. *Habitat effects* – uncertainty in the biological effects of future habitat management actions.

We also considered the following three uncertainties when projecting the effects of drawdown to natural river of the four lower Snake River dams (option A3):

10. *Length of Pre-Removal Period* – the duration of time between a decision to proceed with drawdown and actual removal of dams (pre-removal period) due to uncertainty in the Congressional appropriations process and the possibility of litigation.
11. *Length of Transition Period* – duration of period between completion of dam removal and establishment of equilibrium conditions in the drawndown section of the river (transition period), reflecting uncertainty in the physical and biological responses to drawdown (e.g., short-term response of predators, release of sediment).
12. *Juvenile survival rate once river has reached equilibrium conditions after drawdown* – uncertainty in the long-term physical and ecological effects of drawdown (e.g., change in density of predators).

We call a particular combination of hypotheses for these twelve uncertainties *a prospective aggregate hypothesis*. Each prospective aggregate hypothesis potentially yields a unique biological response to an action. We explored 5,148 different aggregate hypotheses in the preliminary analysis. The revised results are for 2400 hypotheses (240 for A1, 240 for A2, and 1920 for A3), since they include only one habitat management alternative (instead of two) and only two transport assumptions (instead of three). One of our objectives was to determine which uncertainties have limited effects on performance measures and the resulting decision, so that we can focus on the most critical alternative hypotheses. In the final report, we may also develop new variations or combinations of hypotheses that better reflect recent evidence.

We also consider alternative harvest schedules to assess the sensitivity of responses to hydro actions to variations in harvest rate. A number of potentially important factors were not explicitly quantified in the models, although some are considered implicitly in the models to some extent. These include several factors discussed by the Independent Scientific Group in the "Return to the River" report, such as the effects of genetic interactions between populations, and impacts of the hydropower system on conditions in the estuary.

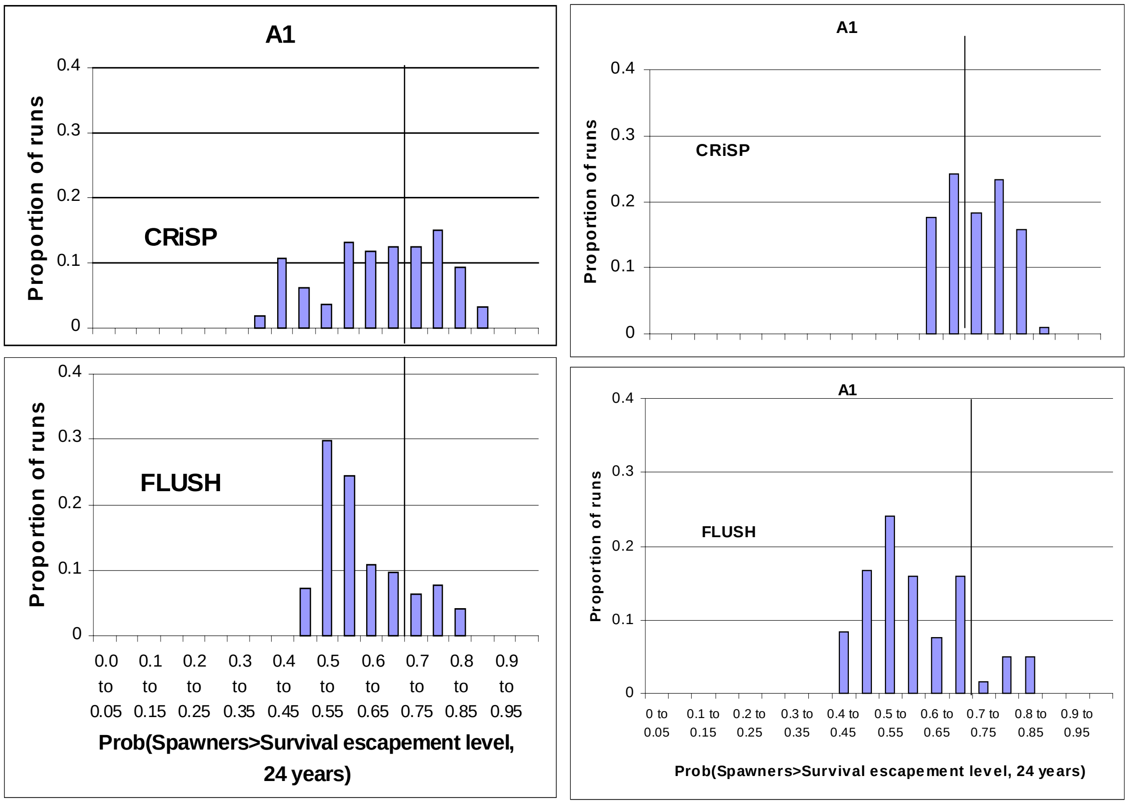
Results

There were five objectives for the results of the preliminary analyses:

1. Explore ways to summarize complex analyses and results into graphs that are easy to understand, interpret, and explain to decision-makers.
2. Provide **preliminary** insights into the relative performance of alternative actions.
3. Identify key uncertainties that affect the results.
4. Test the sensitivity of decisions to the weights placed on key uncertainties, so as to focus the assessment of existing evidence, and the acquisition of additional evidence.
5. Summarize results for some other important performance measures.

Ways to Summarize Results

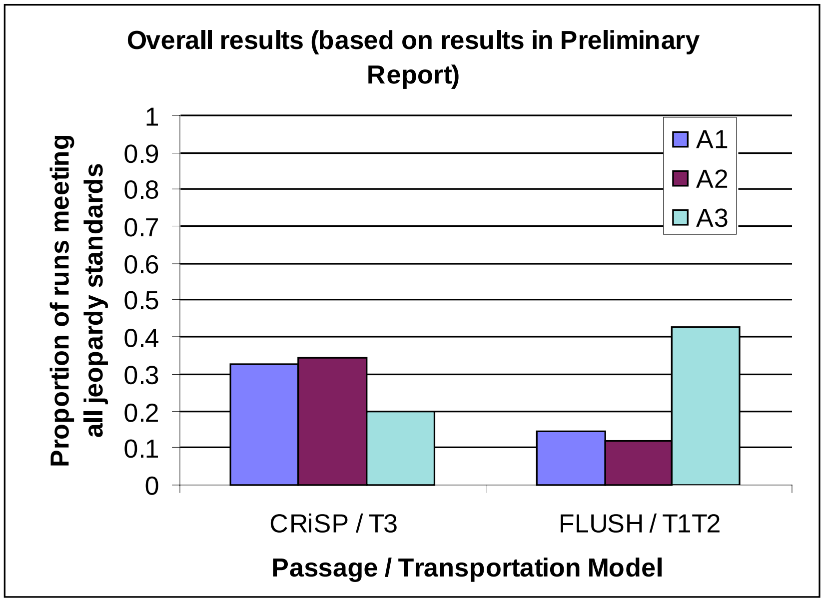
We have generated predicted outcomes for alternative management actions using each possible aggregate hypothesis. Since there are 2400 unique aggregate hypotheses, there are 2400 unique alternative futures that one could examine to evaluate alternative actions. We used two alternative ways to summarize these outcomes. The first was to show a frequency distribution of all outcomes for a single action. This shows the range of possible futures associated with the uncertainties in past, present, and future conditions (an example for Action A1 is shown in Figure E-1). We separated results generated with the CRiSP-TRANS4 passage model and transportation assumptions from those generated with the FLUSH-TRANS1 model because these two models represent fundamentally different approaches to estimating mortality through the juvenile migration corridor and because they are each associated with different assumptions about the relative survival of transported and non-transported fish in the ocean (i.e. CRiSP is associated with transportation assumption TRANS4, while FLUSH is associated with T1. (The TRANS2 assumption will be used in further sensitivity analyses.)).



Original figure in Preliminary Report ↑ Revised results ↑

Figure E-1: Frequency distribution of possible future outcomes of Action A1 using CRiSP-TRANS4 (top) and FLUSH-TRANS1 (bottom) passage models and transportation assumptions. Outcomes are measured as the probability of the spawning abundance of the sixth best stock exceeding the survival level of escapement in the first 24 years of the 100-year simulation period. The height of the bars reflects the relative frequency with which a particular outcome is projected. The vertical line at 0.7 represents the NMFS survival standard; outcomes to the right of that line are considered to have met the 24-year survival standard.

The second approach was to calculate the "expected ability" of an action to meet the NMFS survival and recovery goals. This is essentially the weighted fraction of the 2400 outcomes (or runs) that met the NMFS criteria for survival and recovery, where the weights reflect the relative degree of belief in one hypothesis over another. In the preliminary analysis, all hypotheses were given equal weights. An example of this type of output is shown in Figure E-2.



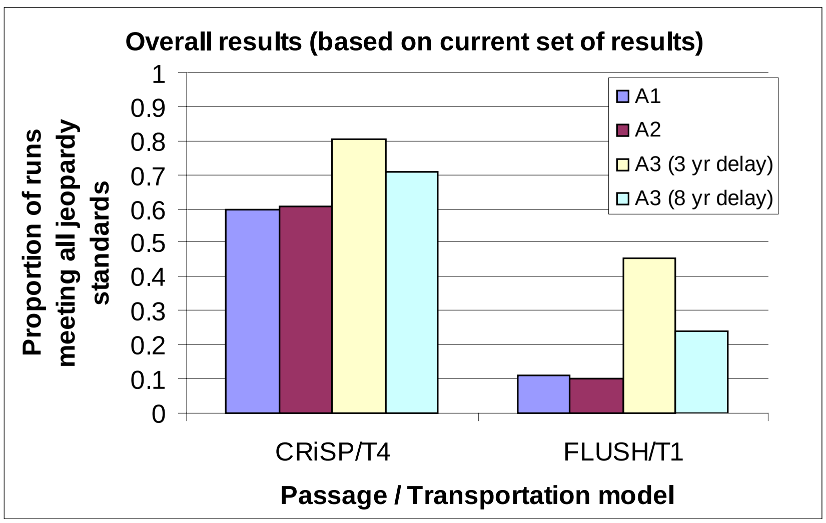


Figure E-2: Proportion of runs with actions A1, A2, and A3 meeting the 24-year survival standard. The standard is met when the spawning abundance of the sixth best index stock exceeds the survival escapement level an average of 70% of the time over the first 24 years in the 100-year simulation period. The top figure is from the Preliminary Report; the bottom figure is from the revised results.

Relative Performance of Alternative Actions (Preliminary results)

1. ***There is a large variation in outputs, even within models and actions.***

   There is considerable uncertainty in the outcomes of alternative management actions. Probabilities of spawning abundances exceeding survival and recovery escapement levels can range anywhere from very low to very high values, depending on the underlying aggregate hypothesis. For example, probabilities of being above the recovery escapement level generated with the FLUSH-TRANS1 passage model range from 0.14 to 0.83 under A1, while CRiSP-TRANS4 probabilities range from 0.34 to 0.84. For both models, there is greater variation in probabilities associated with recovery escapement levels than in probabilities of exceeding survival escapement levels. FLUSH-TRANS1 results for A1 and A2 generally have a greater range than CRiSP-TRANS4 runs. Ranges are similar under both passage/transportation models for A3, except for the 48-year recovery standard where CRiSP-TRANS4 results span a wider range. Since these ranges introduce considerable uncertainty into which decision should be made, it is important to identify the individual components of an aggregate hypothesis that have the greatest effect on decisions.

2. ***Relative performance of the management options depends on passage model assumptions.***

Using CRiSP-TRANS4 passage model and transportation assumptions, the three actions all had very similar fractions of runs meeting the NMFS 24-year survival standard while A3 had a higher fraction of runs meeting both the 100-year survival standard and the 48-year recovery standard. With FLUSH-TRANS1 passage model and transportation assumptions, A3 always has the highest fraction of runs meeting jeopardy standards, followed by A1 and then A2. Drawdown (A3) represents both improved in-river survival and a reduction in transportation.

3. ***Long-term standards are easier to meet than short-term standards.***

The 24-year survival probability is the hardest one to meet (i.e. achieve a jeopardy probability of 0.7 or more) and is a good indicator of the ability of an action to meet all of the standards. This result is illustrated for actions A2 and A3 in Table E-1.

Actions →	*A2*		*A3*	
Models →	*CRiSP-TRANS4*	*FLUSH-TRANS1*	*CRiSP-TRANS4*	*FLUSH-TRANS1*
Standards ↓				
24-yr survival	0.61	0.1	0.76	0.35
100-yr survival	1.0	0.37	1.0	1.0
48-yr recovery	0.73	0.12	0.99	1.0

Table E-1. Revised preliminary results for different actions, models and standards. Cells show fraction of runs meeting a specific standard (shown in the row), under the action and model indicated in the column.

4. ***With this set of actions and unweighted hypotheses, it is only under CRiSP-TRANS4 assumptions that <u>all</u> of the survival and recovery standards are met with a high expected ability (i.e. in more than 0.7 of the runs).***

With CRiSP-TRANS4, the highest fraction of the unweighted runs meeting all survival and recovery standards is 0.76 (obtained with action A3); actions A1 and A2 both meet all standards in about 0.6 of the runs (Table E-1). With FLUSH-TRANS1, the highest fraction of unweighted runs meeting all standards is 0.35 (obtained with action A3), whereas actions A1 and A2 meet all standards in only 0.10 of the runs. We would assume that decision-makers would want a high fraction of runs to meet all of the recovery and survival standards, since that implies a high degree of certainty that these standards will be met.

5. ***Alternative standards and harvest schedules affect the outcomes of management options, but not their relative ranking. {reanalysis to be completed}***

We have not re-examined the sensitivity of the revised set of results to alternative standards and harvest rates. In the preliminary analysis, the ranking of actions was not affected when we applied weaker (i.e. easier to meet) and stronger (more difficult to meet) jeopardy standards than the informal NMFS definition (0.70 probability of exceeding survival escapement levels, 0.50 probability of exceeding recovery escapement levels), although as expected a lower fraction of runs met the stronger standard and a higher fraction met the weaker standard. The ranking of actions was also unaffected when we use two more conservative harvest rate schedules than the one based on current management. In one of these alternative schedules, harvest rates are reduced by one-third from their current values. This change had little or no effect on the fraction of runs meeting survival and recovery standards under any action. In the other alternative schedule, harvest rates of spring-summer chinook are set to 0. Here, the effects were greater than when harvest rates were reduced by one-third; the magnitude of these effects on outcomes depended on the action and passage model assumptions.

We do not yet know how these results are affected by the changes in assumptions described above.

Sensitivity of Outcomes and Decisions to Effects of Uncertainties

To assess the sensitivity of outcomes to other uncertainties, we defined two possible criteria for decision-making, both based on the NMFS Jeopardy Standards. The first is a **relative criterion**, in which the preferred action is the one that simply maximizes the fraction of runs (expected abilities) meeting all three NMFS survival and recovery standards. Because the transportation vs. drawdown question seems to be of most interest in the region, we are concerned primarily with the relative ranking of A2 and A3 in this sensitivity analysis. The second possible basis for decision-making is based on an **absolute criterion**. We assume that some minimum fraction of runs should meet survival and recovery standards for an action to be considered acceptable (i.e. a ‘minimum expected ability’). Since it is not clear at the moment what the minimum expected ability should be, we use 0.7 for illustrative purposes. These criteria are admittedly difficult to meet, since they include the 24-year survival standard (see conclusion #3 above).

6. Within each model, only a few uncertainties have significant effects on outcomes and decisions.

The key uncertainties that significantly affect the decision are (listed in numerical order as they occur on page v of this revised summary): those associated with passage model assumptions (#1), predator removal effectiveness (#4), relative survival of transported and non-transported fish (#5), stock productivity (#6), extra mortality (#7), length of the transition period under drawdown (#11), juvenile survival once the river has reached equilibrium (#12). In some cases, experimental management actions may present the only opportunity for resolving these uncertainties. We plan to have a workshop in late 1998 to explore the feasibility, benefits, and risks of such experiments.

7. The ranking of actions is relatively insensitive to "best" and "worst" case combinations of hypotheses.

We looked at the effects of "best-case" and "worst-case" combinations of passage-related hypotheses, drawdown-related hypotheses, and stock productivity and future climate hypotheses. Best and worst case sets of have predictably large effects on results, but they do not significantly affect the relative ranking of actions under each passage/transportation model as described under point #2 above.

8. Results are similar using a single stock (Minam River).

We used the Minam River as an example because it is most often the sixth best stock. CRiSP-TRANS4 assumptions show virtually no difference between A2 and A3 with the 24-year survival standard, but A3 has more favorable outcomes with the 48-year recovery standard. FLUSH-TRANS1 assumptions favor A3 with all jeopardy standards. The same uncertainties described under paragraph #6 were important for the single stock.

Sensitivity of Outcomes and Decisions to Weightings on Alternative Hypotheses

PATH will attempt to assign weights to those key uncertainties based on the weight of evidence for and against particular hypotheses. The first step in assigning these weights is to establish just how sensitive the decision is to the weightings that are placed on alternative hypotheses. For example, what is the critical weighting that must be placed on the hydro-related hypothesis for extra mortality before the 0.7 threshold is reached? This information can help to frame the assignment of weights by identifying what the critical weights are. Precise framing of this discussion will be particularly important where there is disagreement among PATH scientists and agencies over what these relative weights should be.

Our results indicate that passage model, extra mortality, and best/worst combinations of drawdown hypotheses had the greatest effects on decisions. Unfortunately, these uncertainties will also likely be the most difficult to assign weightings to, because of firmly-held beliefs about the interpretation of historical data and because extra (post-Bonneville) mortality and drawdown effects are the most difficult to measure. Therefore, we looked at the effects of different weightings on these hypotheses on the fraction of runs meeting all three survival and recovery standards (expected abilities).

9. The sensitivity of the ability of actions to meet all of the standards is much more complex than in the preliminary analysis. The ability of actions to meet all of the jeopardy standards depends on the weights placed on extra mortality and stock productivity hypotheses. The particular hypotheses that determine whether the actions meet all of the standards depend on the passage / transportation model.

All jeopardy standards are met under FLUSH/TRANS1 for actions A1 and A2 only if we are absolutely certain (i.e. weight = 1.0) that both the Delta model and the hydro extra mortality hypothesis are correct (or, that both the Alpha model and Regime Shift hypotheses are incorrect; see Figure E-3a (new)). The weight placed on the hypothesized effectiveness of the Predator Removal program is also important for A1 and A2 under FLUSH/TRANS1. For A3, less certainty about these hypotheses is required for all actions to meet the standards (the degree of certainty also depends on the weights placed on hypothesized lengths of the transition period following drawdown).

With CRiSP/TRANS4, a high weight must be placed either on the regime shift extra mortality hypothesis or the hydro extra mortality hypothesis before all actions are projected to meet all of the standards (see Figure E-3b below for an example). The degree of weight that must be placed on the extra mortality hypotheses to meet this criterion depends on the weight placed on the stock productivity hypotheses and (for A3) the length of the transition period. In general, if a higher weight is placed on the Delta model, a lower weight must be placed on the regime shift or the hydro extra mortality hypothesis for the actions to meet all of the standards.

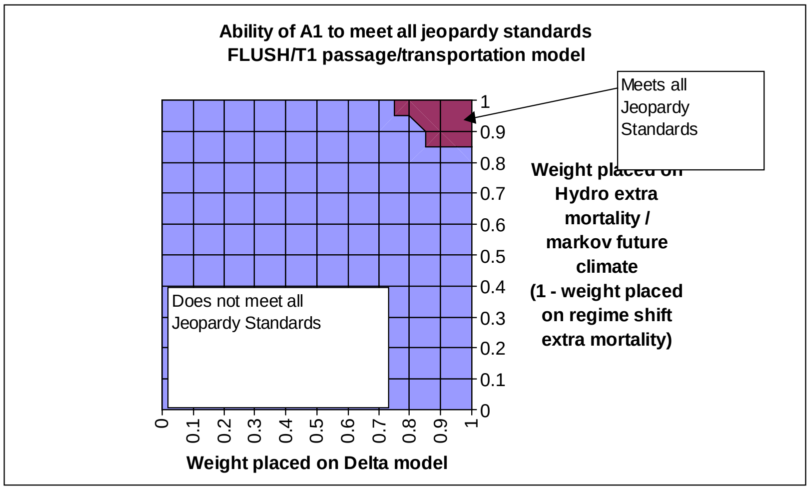


Figure E-3a (new). Sensitivity of the ability of A1 to meet all of the jeopardy standards under FLUSH/TRANS1 to weight placed on the stock productivity (bottom axis) and the extra mortality hypothesis (side axis). Hypotheses about the effectiveness of the predator removal program are weighted equally in these results. Note that in this example we are switching weights between the Hydro and the Regime shift extra mortality hypothesis (i.e. the weight on the BKD hypothesis is assumed to be zero).

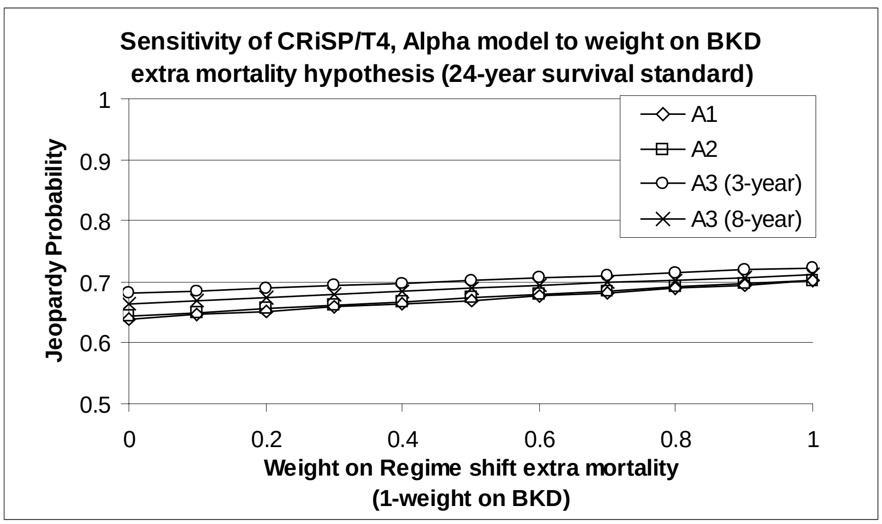


Figure E-3b (new). Sensitivity of the ability of the actions to meet the 24-year survival standard under CRiSP/TRANS4 to weight placed on the regime shift or BKD extra mortality hypothesis. The 24-year survival probability is the hardest one to meet (i.e. achieve a jeopardy probability of 0.7 or more) and is a good indicator of the ability of an action to meet all of the standards. Results are shown only with the Alpha model; jeopardy probabilities with the Delta model are generally higher. In this example, the weight on the hydrosystem extra mortality hypothesis is assumed to be zero.

10. Under both CRiSP and FLUSH, A3 is more likely to meet all of the standards when a high weight is placed on a short pre-removal and transition period. The weights that are required for the drawdown hypotheses depends on the weights placed on the other key hypotheses.

A3 under FLUSH-TRANS1 and CRiSP-TRANS4 was more likely to meet all of the standards when it was certain that the pre-removal period was three years, and the transition period two years. If the weights on these hypotheses are high, then the assumptions about equilibrated juvenile survival rate did not matter as much. CRiSP results are less sensitive to the drawdown hypotheses than FLUSH results.

11. Key uncertainties are unlikely to be resolved with existing data.

There will have to be considerable agreement on several key uncertainties (in-river survival, transportation assumptions, extra mortality, stock productivity, and drawdown assumptions) before A1,A2, or A3 are clearly able to meet the survival and recovery standards. The PATH weight of evidence process is designed to quantify the degree of belief in these uncertainties. However, given the lack of data that gave rise to the uncertainties, and the strongly-held beliefs which fill in data gaps, this consensus is not likely to be achievable without a well-planned experimental design that is specifically directed towards answering questions about extra mortality and passage model assumptions.

Other Performance Measures

The NMFS jeopardy standards are only one of a number of different measures of performance produced by PATH modeling analyses. In the Preliminary report, we also briefly reported results for two additional measures: projected harvest rates, and Smolt-to-Adult survival rates from the time they pass the upper-most dam as smolts to the time they return to that dam as adults. We have not had time to repeat these additional analyses for the revised set of results, so we are unable to say whether the results in sections 12 and 13 have changed. We will explore these additional performance measures in the final PATH report.

12. Projected harvest rates are highly variable. {reanalysis still to be completed}

We showed an example of the trends in mainstem harvest rates for a single stock (Imnaha), and a single action (A1) over time. We showed this for an optimistic aggregate hypothesis and a pessimistic hypothesis. In most years, harvest rates can range from below 0.1 to above 0.35 for a particular scenario. Such uncertainty is important to communicate to decision-makers and to others who will be using this information, such as the economic workgroup.

13. Median SARs of between 2 and 7% are associated with meeting the 100-year survival standard. {reanalysis still to be completed}

This is consistent with the interim SAR goal of between 2 and 6% identified by the PATH hydro workgroup (Ch. 6 in PATH FY1996 Retrospective Report). Note that these 'median SARs' are computed over a 100-year period.

In addition to quantitative performance measures, we would also like to look at how well the alternative management actions do in terms of qualitative measures of performance such as the concepts discussed in the ISG's "Return to the River" report. Such qualitative measures can allow us to incorporate less quantitative but nonetheless important issues relating to the relative health of individual salmon populations, aquatic communities, and entire ecosystems.

Again, we caution that these results are preliminary. We emphasize that these results do not incorporate the weights being developed through the weight of evidence process, assume status quo habitat management, and do not consider new hypotheses. Review of this preliminary analysis has lead to refinements in methods and consideration of additional alternative hypotheses. These improvements will be incorporated in the final decision analysis report for spring/summer chinook. The final report will also present analyses of additional management actions to those evaluated in this report (including drawdown of John Day Dam), and will endeavor to reach consensus to the maximum extent possible on the relative weights assigned to alternative hypotheses based on the strength of supporting evidence and our professional judgements. We anticipate, however, that lack of evidence will constrain our ability to reach consensus on the relative likelihood of some alternative hypotheses.